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THE ORIGIN AND PURPOSES OF BLINKING*†

BY

Sir ARTHUR HALL, M.D., D.Sc. (Hon.), F.R.C.P.

EMERITUS PROFESSOR OF MEDICINE, UNIVERSITY OF SHEFFIELD

THIS enquiry was begun some years ago in order to find out to what extent the rate of blinking is reduced in the chronic encephalitic. As there were no normal standards taken under such special conditions as the encephalitics were, alone, capable of carrying out, it was necessary in the first place, to obtain such in a corresponding number of normals. It was in the course of these preliminary tests on normals that certain unexpected points were noted in the records. As they promised to throw some light on the purposes of blinking in general, further varieties of tests on normals were carried out. It is with these, and their results, that this paper is chiefly concerned. In all the tests three important principles were complied with: (i) All the persons tested were unaware that their blinking was being watched. This was secured by various mild deceptions.

(ii) In each test the surroundings and procedure were the same for all.

(iii) All stimuli capable of causing local reflex blinks were excluded.

* Received for publication, June 15, 1945.

† The term blinking, is used throughout this article to mean those acts of bilateral closure of the eyes, which, though slightly variable in duration, are never more than momentary.[4]

PART I—EXPERIMENTAL

Test 1—Rate of blinking in encephalitics as compared with that of normals

FOR this and for Test 2, the examinee and the two observers were seated on three sides of a square table, on which was the Mackenzie polygraph. Observer (A) watched the blinks and recorded them by means of a rubber teat connected with one of the levers. The teat was held out of sight under the edge of the table. Observer (B) worked the polygraph, and directed proceedings generally. The examinees were told that it was their "rate-of-breathing" that was being tested, and to re-inforce the suggestion, a broad canvas belt was fastened round the chest, from which an insulated wire passed to the supporting arm of the polygraph! The arrangement in both parts of the test were such that Observer (A) was able to see every blink, without the examinee's knowledge. The test consisted of two parts; reading a short story *aloud,* and, secondly, talking to observer (B). *Reading aloud* ensured that they were reading continuously, and not merely thinking about something else whilst gazing at the book. In this paper the word reading always means reading aloud.

Altogether 57 encephalitics and 57 normals took part in this test. Of each there were 37 males and 20 females. Twenty-eight of the encephalitics, owing to their various disabilities, could not carry out the reading test. Most of these were the more advanced Parkinsonians, in whom the average rate of blinking when in conversation was only one half that of the others; in seven of them it was less than two per minute, whilst in one there was only one blink in 5 minutes.

The rates obtained were as follows:—

Conversation period	Average blinks per minute M. & F.	M. only	F. only
57 Normals (M. 37, F. 20)	25·4	29·3	18·3
57 Encephalitics (M. 37, F. 20) ...	10·6	11·5	8·8
Reading period			
29 Normals (M. 17, F. 12)	3·29	3·57	2·58
29 Encephalitics (M. 17, F. 12) ...	2·9	3·9	1·4

From the above figures it would appear that there is some fundamental difference between the blinks when in conversation, and those when reading aloud, and that the attack of encephalitis has

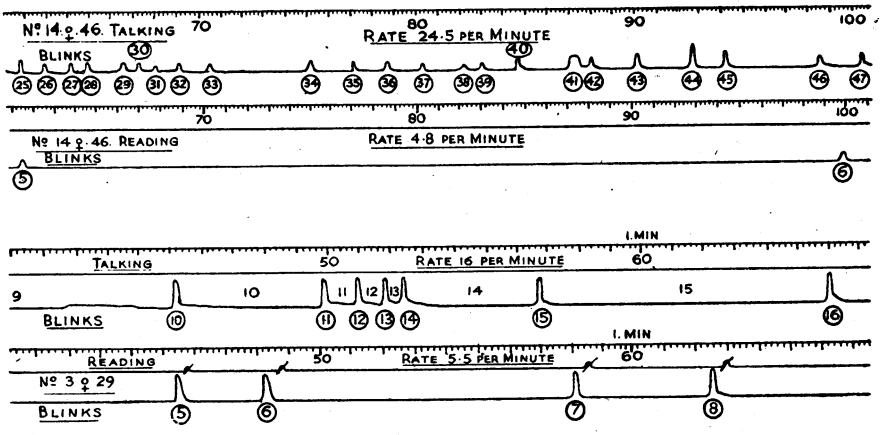

PLATE 1.

Test 1. Parts of original polygraph records of blinks in two normal females, showing, above, when in conversation with strangers, and below, when reading aloud under the same conditions and surroundings. Time-marker, 1/5th seconds.

reduced the number of the former whilst not materially affecting the latter. The remaining tests are limited to persons in normal health.

Test 2—The places at which blinks occur in Normals when reading aloud

In the previous test it had been frequently noticed that a blink occurred at " turning-over-the-page," whilst others coincided with " ends-of-sentence " or other punctuation-marks. In order to confirm these findings further tests were made on Normals, in which the exact times of these " events " were recorded on the polygraph alongside the blinks, by means of the second lever. This was connected with a rubber teat held out of sight by Observer B. The matter read was the same short fairy story as in Test I. The book was post octavo size, with lines $3\frac{1}{2}$ inches long. The story contained 660 words, printed on the two sides of one page, so that there was one " turn-over " about half way through. Everything was carried out exactly as in Test I except that a period of, what may be called, " trick-reading " was added to the other two periods, as will be explained shortly.

Sixteen normal adults (M. 9, F. 7) were examined, all of whom were complete strangers to the place and to the Observers.

The following were the average rates of blinking in the two periods, as in Test I :—

Conversation period		rate per minute
16	Both sexes	19·8
9	Males	20·1
7	Females	19·4

The total number of blinks of the 16 persons was 1,191.

Reading aloud period		Average rate per minute
16	Both sexes	2·8
9	Males	1·5
7	Females	3·8

The total number of blinks in the 16 persons was 139, *i.e.*, about one-eighth of the number when in conversation.

A further point to notice is that, whilst the average rate when in conversation is practically the same in the two sexes, in the reading aloud period the average rate in the females is considerably more than double that in the males. This is directly connected with the greater efficiency of the females as " readers." Indeed the 16 examinees could be placed in three classes as readers: (A) Good, (B) Average, and (C) Bad. In (A) there were six (F. 5, M. 1), in (B) six (F. 2, M. 4), whilst the four in (C) were all males.

Grouping of blinks when reading

The 139 blinks could be grouped as regards the places at which they occurred into three categories, as follows :—

(i) At turning-over-the-page	12
(ii) At punctuation marks	118
(iii) At other special points	9
	139

Omitting (iii) for detailed consideration later, it is seen that whilst the blinks of (i) are at a " physical " gap in the matter read, which calls for a change in the direction of fixation to a point at the moment out of sight, yet in the much larger number of (ii) no such change of direction is required. When the blink is over fixation is resumed at the same point.

The blinks of (i) and (ii) were much more numerous in the readers of Classes A and B, the good and the average, than in Class C, the bad. In three out of the four last-named there were no blinks at all during the whole reading-period. That there is an essential difference between the blinks at physical gaps in the text, and those at punctuation marks (blinks of " technique ") was made clear by a form of " trick-reading," as follows :—

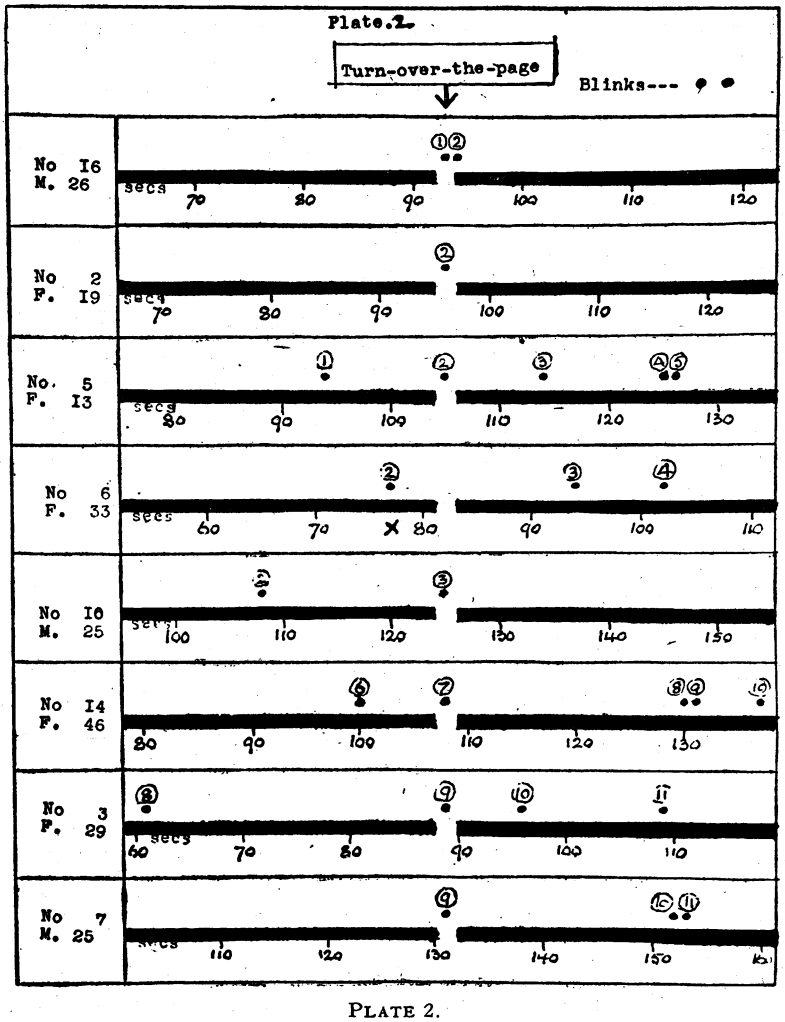

PLATE 2.

N.B. In this and in Plates 4, 5 and 6, the polygraph tracings have been compressed so as to show more of their length or the whole length. The time is shown as a straight black line with the number of seconds in figures above. Blinks are shown as "dots" with or without a circle around them.

Test 2. Parts of compressed polygrams from eight persons (normals) showing blinks at "turning-over-the-page" when reading aloud. The blank in the time line corresponds with the turn-over in each person. No. 6. In this very good reader, her blink (marked x) did not occur at the actual turn-over, but about 3 seconds before, at the moment at which she took hold of the bottom corner of the page, raising it slowly before turning it quickly, as she finished the page. This was probably a blink of technique, rather than "at-a-physical gap."

Reading-down-in columns (trick-reading)

For this a similar short fairy story was typed in 14 vertical columns (Plate 3). Each 8½ inches high, with one word only in each line. Each column is read in turn from top to bottom, and then continues at the top of the next column. There is no "turn-over" but, instead, 13 "physical gaps" at going from one column to the next. The punctuation marks are all inserted. The changes in the number and distribution of the blinks in these 16

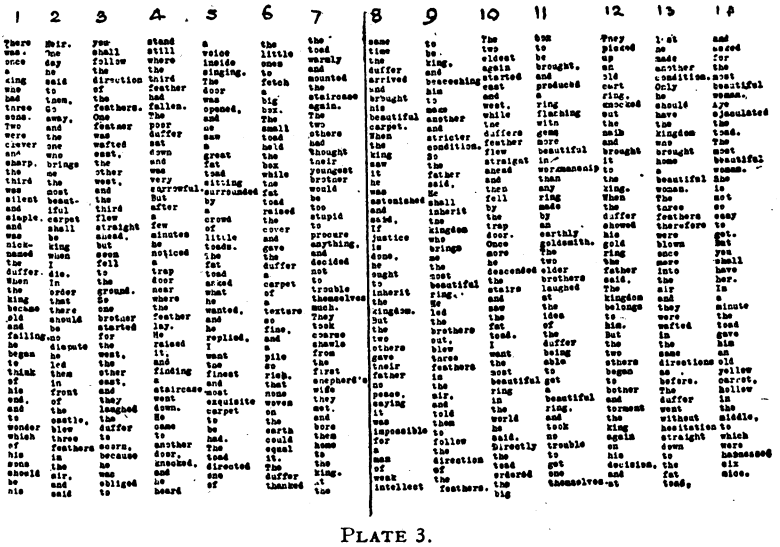

PLATE 3.

Test 2. Typed script used for "Reading down" (Trick-reading). Begins at top of column 1, down to the bottom; from there to top of column 2, and so on to the end at the bottom of column 14. The numbers at the tops of the columns have been added since the tests. The whole was in view at the same time so that there was no "Turn-over."

normals was very striking. The total number had fallen from 139 to 88, and their distribution was quite altered, as follows:—

Category	No. of Blinks
(i) Gaps at changing columns	69
(ii) Punctuation marks	16
(iii) Other special points	3
	88

Thus with the increase of "gaps" from 16, at turn-over, to 208 at column changes the blinks of (i) had gone up from 12 to 69. With the novelty of the setting the blinks of "technique" had fallen from 118 to 16.

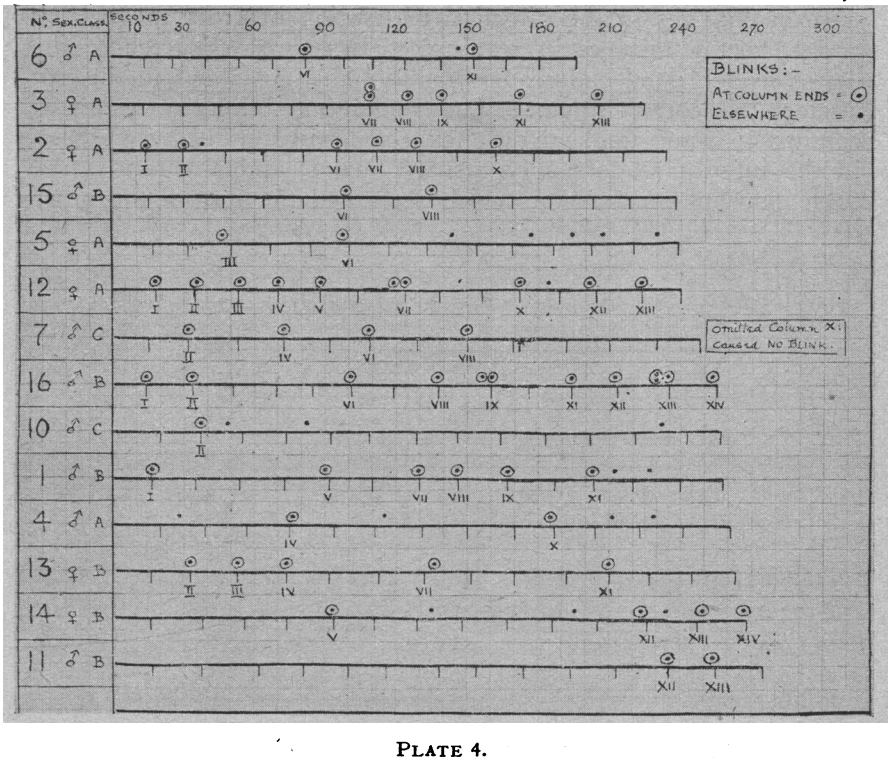

PLATE 4.

Test 2. Compressed polygrams (whole-length) of fourteen normals when reading-down in columns. Class of reader, A, B, or C, is given alongside the sex. Time of changing column shown as short vertical lines from horizontal time-record. Blinks at column changing down by dot with ring round; blinks at other places by dot only. Time in seconds shown above.

The better readers had been completely thrown out of their stride, as readers, and, *quâ* the observance of punctuation marks, reduced in technique to the level of the inferior classes. That is to say, they ignored most of them.

Reading-down period	Average rate per minute
16 Both sexes	1·3
9 Males	1·0
7 Females	1·6

Total number of blinks: 88.

The blinks of category (iii) when reading (ordinary text)

One of the nine was an "Aural-reflex blink," caused by a sudden noise (interruption from without). Four of the remainder

were at changes in the direction of fixation in order to go back and correct a mistake in reading. These only occurred in the better readers; the bad readers made many mistakes but did not attempt to correct them. The remaining blinks were when coming to some unusual or unexpected word. They were seen in the inferior readers only, usually males, and apparently had some psychological factor which separated them from the other

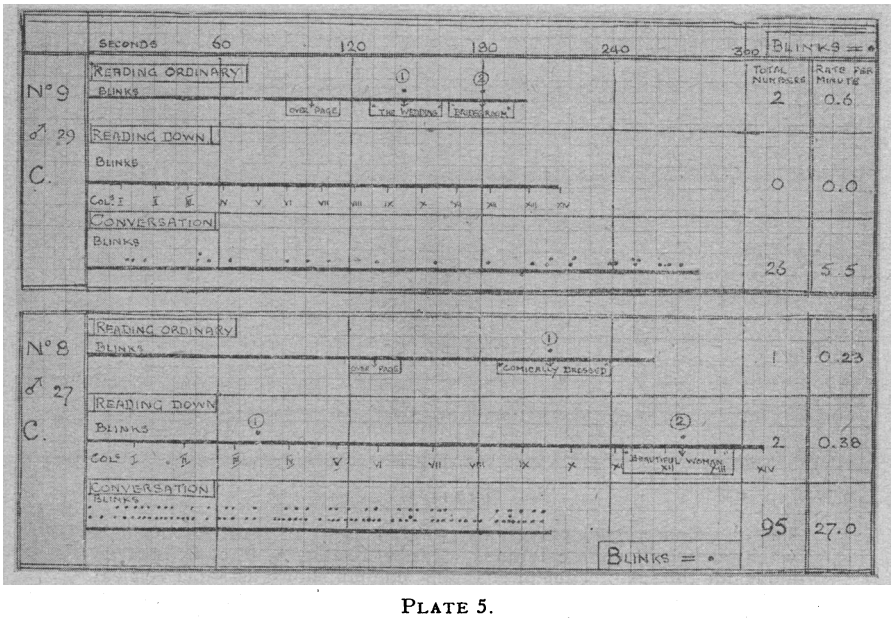

PLATE 5.

Test 2. Compressed full length polygrams of two normals, both inferior readers, class C, and young males. Each is recorded when reading-aloud (ordinary), reading-down, and in conversation. Note the extreme rarity of blinks in either form of reading, their absence at "turn-over" and their occurrence at special words. Also the wide difference of rate when in conversation.

groups. Some of the words had a certain "sex-association." One was "The Queen," another "Beautiful woman." One man blinked first at the words "for the wedding" and later, at "Again the Bridegroom."

Physical gaps.—As regards the question of what constitutes a "gap" sufficient to call for a blink, it is evident that the end of one line to the beginning of the next below *does not,* either in post-octavo size, or, as is well-known, in much larger sizes. If, however, the lines are much longer, blinks may occur at their ends. This was demonstrated in one male, the only person tested in this way. The same story was typed in Brief-form,

with lines 18 inches long. In reading this he blinked at the end of 6 out of the 22 lines, although when previously reading from the post-octavo book he had not blinked at the end of any. His ocular automatism for reading had not been trained for such long changes in the direction of fixation.*

Test 3—The relation of blinking to changes in the direction of fixation

For this the examinee was seated facing the observer, about five feet away. As it was obvious that his eyes were being watched, each person was told that the accuracy of sight, under exceptional conditions, was the subject of the investigation.

Fifty normal adults (M. 17, F. 33), none of whom had taken part in either of the two previous tests, were examined in the following three ways :—

(A) With fixation maintained on a centrally placed object whilst it is moved from side to side.

(B) With fixation changing in direction from one central stationary object to other stationary objects, on his right and left.

Each of the above was done in two parts (i) with head *free*, and (ii) with head *held*, by the Nurse, who placed the palm of the hand on each side of the examinee's head, and held it firmly.

(C) With fixation maintained on a central object which remained stationary, whilst the examinee rotated his head freely to right and to left.

Results of (A)

The object to be looked at was the upheld finger of the Observer whilst it was moved horizontally to and from the extreme right and left.

Results

(i) Head-free.

	No. of persons	No. of blinks
	1 (F.)	2
	2 (M. 1, F. 1)	2
	47 (M. 16, F. 31)	0
Totals	50	4

The female who blinked twice was very nervous.

(ii) Head-held.

	2 (M. 1, F. 1)	2
	48 (M. 16, F. 32)	0
Totals	50	2

* My grateful thanks are due to the out-patient sister at the Sheffield Royal Hospital, Miss Milton, who as observer (A) was responsible for the recording of the blinks throughout Tests 1 and 2.

The two who blinked here had not done so with head free. None of the 6 blinks occurred at points where the direction of movement of the object was being changed.

Results of B

The stationary objects were three large cards hung on the wall behind the Observer, and about seven feet from the examinee. No. 1 was in the centre, Nos. 2 and 3 on his right and left respectively, about seven feet apart. He was asked to look first at No. 1, then at No. 2, then back to the central, 1, then to 3 and back again to 1. There were thus *four* changes in the direction of lateral fixation. The important instruction was added that none of these changes should be made until *told by the Observer to do so.*

Results

Changes in direction of fixation at which a blink occurred	Number of persons (i) Head-free	(ii) Head held
At Four	21 (M. 7, F. 14)	12 (M. 3, F. 9)
At Three	7 (M. 2, F. 5)	5 (M. 0, F. 5)
At Two	9 (M. 4, F. 5)	4 (M. 0, F. 4)
At One	6 (M. 2, F. 4)	11 (M. 6, F. 5)
At None	7 (M. 2, F. 5)	18 (M. 8, F. 10)
	50	50

It is seen that, with head-free (i), more than four-fifths blinked at one or more changes in direction of fixation, of whom nearly a half did so at every change, whilst, in nearly one-fifth, there was no blink at any. With head-held (ii) the blinks were reduced considerably in some, in others, not at all. In the seven who did not blink in (i), there were again none in (ii). On the whole the effect of holding the head reduced the rate of blinking rather more in the males than in the females.

N.B.—In a further short series of normals these tests were repeated with the head rigidly fixed in a metal clamp for (ii). The results were practically the same as above. One man who had blinked at all four changes with head-free, did the same with head-clamped; another did not blink at any change, either with head-free or clamped.

Results of (C)

For this the object on which fixation was to be maintained was, as in (A), the finger of the Observer held straight in front of the examinee a few feet away, but whereas in (A) it was moved from

side to side, here it was kept stationary, whilst the examinee was asked to turn his head first to one side then to the other, whilst still keeping his eyes on the finger.

N.B.—So intimately associated is the lateral movement of the head with that of the eyes, that several found it difficult to keep the eyes fixed on the object as soon as they got the head moving to the side. In such it was more easily done, and produced a perfect result if they were told to *move the chin* laterally as far as they could whilst looking at the finger. The result, quâ movement of the head, was the same.

Results.

In 38 (76 per cent.) out of the 50 there was no blink throughout. Of the remaining 12, one nervous woman blinked four times, but none of them were at any point where there was a change in the direction of movement of the head. In most of the other eleven, each of whom gave one blink only, this was usually at the return from the extreme end, or when passing the middle point and going to the other side. One man moved his head with such freedom and vigour, on going to the right, that he overshot the position at which the object was still visible, and had to blink to bring it in view again.

No. of persons				No. of blinks
38	(M. 11, F. 27)	gave no blinks		0
11	(M. 6, F. 5)	gave one blink		11
1	(F. 1)	gave four blinks		4
50				15

Test 4—Blinking in the blind

Polygraph records were made of the blinking in three children, two brothers, congenitally blind, and another boy, nine years old, totally blind since five years of age. Each boy was in conversation with a stranger, during the whole period of the record, the conditions being similar to those described in Test I. Their respective rates differed, from 22·5 blinks per minute to 7·5. The accompanying Plate gives the distribution of the blinks and alongside each, for purposes of comparison, is the record of one of the normal series from Test I, whose blinking was at about the same rate. In the distribution of the blinks, the records of the blind are indistinguishable from those of the normals.

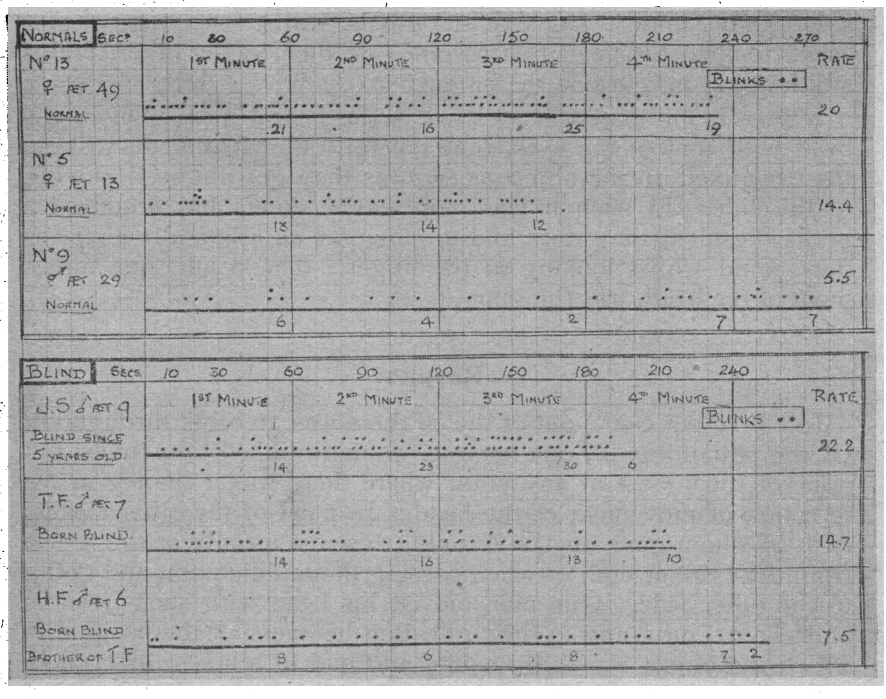

PLATE 6.

Test 4. Compressed full length polygrams of three blind boys when in conversation with a stranger, and of three normals under the same conditions. Each of the latter has been chosen as comparable in rate with one of the three blind. One of the latter, H.F., is certainly of congenital origin, whilst his brother, T.F., is practically so.

Name	Age	Sex	Vision	Rate per minute	Blinks in successive minutes					
					I	II	III	IV	V	VI
H. F.	6	M.	Blind (congen).	7·5	8	6	8	7	2 ($\frac{1}{4}$ min.)	—
No. 9	29	M.	Normal	5·5	6	4	2	7	7 ($\frac{1}{2}$ min.)	—
T. F. ...	7	M.	Blind ? congen.	14·7	14	16	13	10 ($\frac{1}{2}$ min.)	—	—
No. 5...	13	F.	Normal	14·4	13	14	12 ($\frac{3}{4}$ min.)	—	—	—
J. S. ...	9	M.	Blind at 5 years	22·2	14	23	30	6 ($\frac{1}{3}$ min.)	—	—
No. 13	49	F.	Normal	20·0	21	16	25	19 ($\frac{5}{6}$ min.)	—	—

Valued help in obtaining the above was given by the Superintendent of the Sheffield School for the Blind.

Since these records were made, Dr. A. B. Nutt, Medical Officer to the School, has obtained the aural, or acoustic, reflex blink in one of the congenital blind boys (H.F.). This has such an important bearing on the aetiology and purpose of blinking that it will be dealt with more fully in a later section.

Summary of tests

Test 1.—The average rate of blinks per minute in the chronic encephalitics, when in conversation (10·6), was less than half that of the normals (25·4), yet when reading aloud the rate in the two groups was practically the same (encephalitics 2·39, normals 3·29).

Test 2.—When reading aloud most of the blinks occur at certain points in the text, either (*a*) at " physical gaps " in the print requiring a change in the direction of fixation, or (*b*) at marks of punctuation, calling for slight pauses in the flow of words, to express the meaning of what is being read. These are part of the acquired " technique." The difference between these two groups of blinks was emphasised by an unusual way of setting the type in vertical columns instead of horizontal lines (reading down).

Test 3.—So long as fixation on an object was maintained (watching), there was no blink in more than 90 per cent. of normals* either (i) when the object and the head were both stationary and the latter free or held, or (ii) when the object was stationary but the head free and rotated from side to side, or (iii) when the object was moved from side to side, and the head free or held.

On the other hand, when the stationary objects were multiple and separated at a distance from one another, so that the direction of fixation had to be changed on looking from one to another (looking about), a blink occurred *at the beginning* of the change of direction in 86 per cent. of the normals when the head was free, and in 64 per cent. when the head was held. In 14 per cent. there was no blink at change of direction of fixation under either condition of the head.

Test 4.—In three blind children, when in conversation with a stranger under the same conditions as in Test 1, blinking occurred, the records of which, in appearance, frequency and grouping, were indistinguishable from those of normals. The aural or acoustic-reflex blink was observed in one of them, a congenital-blind boy.

* In the rather complicated and varied requirements of Test 3, some of the examinees got confused and nervous, and blinked at odd times. This was especially so in part (ii) where the head only is turned, the eyes fixed on the object.

PART II—VARIETY OF BLINKS IN MAN

Blinks may be either voluntary (Group A) or reflex. The latter, with which this paper is alone concerned, may be placed in at least three distinct Groups (B), (C) and (D).

Reflex or automatic blinks.—Group (B). These are solely for the protection and efficient action of the eyes themselves. Of them the chief are the "corneal- or tactile-reflex" and the "dazzle-reflex," each of which is only aroused by appropriate external stimuli. They are often prolonged until the nocuous stimulus is got rid of.

With these may be included certain blinks described by Duke-Elder[3] and others, which aid the circulation of the intra-ocular fluids.

The old view that there are special blinks for keeping the surface of the eyes moist seems improbable. Ponder and Kennedy[9] in their experiments found no increase of blinks in the hot dry atmosphere of the Turkish bath, and, as is well known, the eyes of the chronic Parkinsonian do not become unduly dry, though he may, for years, only blink once every two or three minutes. Undue dryness at any time is probably dealt with by the corneal, or tactile-reflex.

Group C.—These are for the preservation of the organism as a whole, and are in no way concerned with the efficient action or protection of the eyes themselves. They form the majority of the blinks in daily life. They are so brief that they do not interrupt vision, and we are unaware of their occurrence. Ploman, Engel and Knutson[8] give 0·4 secs. for the total duration, with 0·15 secs. for the complete covering of the pupils. They vary in frequency and purpose, according to circumstances.

Group D.—These are blinks of "technique," seen in the special act of reading aloud. They are conditioned reflexes acquired in the training for this art. They vary in duration with the requirements of the text, and the taste of the reader. They are seen at the marks of punctuation.

It is with the blinks of Groups C and D that this paper is alone concerned.

Purposes of blinks in Group C

Seeing that blinks, indistinguishable from those in man, occur to a variable extent in most vertebrates, a review of what is known as to their occurrence in these latter, living under more simple and primitive conditions may help to explain their purposes in the former. The primary object of every living thing is to reproduce its kind. For this it must obtain food and avoid being killed.

The carrying out of these two functions, is of such importance, that it is ensured by involuntary unconditioned reflexes.

In all animals there are two such inherited unconditioned reflexes which Chavasse[2] calls that of " Aggression " and that of " Self-preservation " respectively. They are opposed, and cannot both be in action at the same time. The extent to which each is required, and used, differs in different species. In the carnivora, or " hunters," aggression, *i.e.*, attack, is their sole means of getting food, which is usually at a distance away, mobile, and actively resistant. On the other hand, to them, the reflex of self-preservation is of much less importance. Attacks from other carnivora are but rare, and are often met by active resistance rather than by flight.

In the Herbivora, or " hunted," it is the reverse. Their food calls for no aggression; it is close beside them, stationary, and non-resisting. On the other hand self-preservation, either by hiding or by flight, is of constant and paramount importance to save them from their carnivorous fellows. This is attained by Pavlov's[7] Investigatory or Where is it? reflex; " If the animal were not provided with such a reflex its life at every moment would hang by a thread." In each of these unconditioned reflexes all the receptor, or sense-organs, act together as one, in order to give the fullest information to the nerve centre as to its surroundings. Whilst in some animals, the senses of smell and of hearing are more informative than they are in man, yet in most, as in him, the eye is the receptor of primary importance. It is the part which the eyes take in these two opposed reflexes which closely concerns the blinks of Group C, because, for each, they must be differently " adjusted," and these two adjustments cannot be in action at the same time. As Holmes puts it,[5] " There are two distinct and *opposed* (italics ours) cortical ocular reflexes, the one, which is excited by extra-macular stimuli, effects movements of the eyes; the other, of macular origin, holds an object in central vision, either by maintaining the posture of the eyes, or by moving them appropriately when, either the object, or the subject's head, moves in space."

Of these two ocular reflexes, the extra-macular, when in action, is receiving stimuli from every point in the field of vision, whilst so long as the macula is acting, only such stimuli as fall on that small portion of the retina which is differentiated from the remainder of it are reaching the nerve-centre with full intensity. In other words the area of the field of vision has been reduced in size, but increased in visibility; the " high-power " has, for the time, replaced " the low-power " objective. Whilst below the level of the primates the macular reflex (true fixation) is not fully developed, yet in all vertebrates there seems to be some, even if

but slight, special differentiation of the retina in its temporal part (Chavasse[2]). With this proviso the terms macular and fixation will be used here as synonymous.

The extra-macular is the more primitive in origin, of more vital importance for self-preservation, and, even in man, the master-reflex of which, from the first, fixation has been the servant, to be called to action, or dismissed, as its master requires. As James[6] puts it, " The main function of the peripheral parts of the retina is that of sentinels, which, when beams of light fall over them, cry ' Who goes there? ' and call the fovea to the spot."

In the lower animals it is only, as in the carnivora, for purposes of aggression, that the fixation reflex is kept in action for long periods when watching their prey. Indeed this association between prolonged " watching," or " staring without blinking " and the carnivore is recognised in many familiar expressions, such as, " He stared at me as though he wanted to eat me!" or the simile " Like a cat watching a mouse!" In the herbivora, on the other hand, prolonged fixation is rarely required. If the object is an enemy, the head is at once turned away, and immediate steps are taken to escape danger; if it is not, interest in it soon ends and fixation ceases, because so long as high-power objective is on, the eyes are not in action for self-preservation.

As will be shown in the following section the rate of blinking in the carnivora is much lower than that in the herbivora.

Blinking in the lower animals

Blount's[1] observations, at the Edinburgh Zoo and elsewhere, show that in most of the lower animals, blinking occurs which is indistinguishable from that seen in man, but at an average rate lower than that seen at the level of the primates. If the rates that he gives are separated into those of the herbivora and those of the carnivora respectively, it is found they are considerably higher in the former than in the latter. Thus:—

Rates of blinks per minute

Herbivora		Carnivora	
Goat	2	Cat	less than 1
Alpaca	2	Lion	less than 1
Bison	6	Dog	2
Camel	8	Leopard	2
Deer	10	Fox	less than 4
Elephant ...	16		
Horse	20		
Cow	22		
Average ...	10·5	Average	less than 2

This difference in rate of blinking in the two groups corresponds with the relative importance to each of self-preservation and aggression respectively, and is accompanied by a different "setting" of the eyes in the head. In the herbivora they are more lateral in order to give the widest possible field of vision, especially to their defenceless rear; in the carnivora they are looking more forward so that the prey in front of them may be more easily watched.

Chavasse[2] gives the following figures for the angle gamma, in the two groups:—

Herbivora	from 80° in the Hare, to 40° in the Pig.
Carnivora	from 45° in the Dog, to 10° in the Lion.

The fact that the blinking-rate is higher in the "hunted" than in the "hunting" animal suggests that its purpose is connected with the self-preservation reflex.

This is confirmed by the occurrence of two well-recognised reflex blinks, seen in the lower animals at "threats of alarm."

These are:—

(*a*) The aural- (or acoustic) reflex blink.

(*b*) The menace-reflex blink.

The former (*a*), follows an unexpected or strange sound from near or from afar. Blount[1] saw it in the elephant at hearing the click of his stop-watch.

The latter (*b*), follows the sudden appearance of some threatening object in the near field of vision. Rademaker and Garcin[10] produced it in the cat, by a menacing action of the fist.

Both (*a*) and (*b*) are seen in the primates and in man under similar threats of danger.

Blinking in the arboreal primates

Blount[1] gives the following figures:—

Chimpanzee	11·1 (eleven)	per minute
W. Indian monkey ...	13·6	per minute
Sudanese monkey	45	per minute

This gives an average of about 24 per minute which is higher than that in the lower animals.

Such increase cannot be ascribed to a greater need for self-preservation, because, although, as herbivora, they are still "hunted" animals, they have acquired considerable security from their terrestrial enemies by taking to life in the trees. Nor are the primates aggressive although the setting of their eyes, in contrast to that of the lower herbivora, is even more "forwards" than that of any of the aggressive carnivora. Their angle gamma, is only 5 degrees. The fact is that with the setting free

of the forelimbs for purposes other than locomotion, a new use for the fixation-reflex has become essential in order to guide and control their movements in all the many purposes to which they are applied. For these, fixation is no longer the long-continued "watching" of aggression but constant changes in direction according to the nature of the action in progress. Together with this, vision has become binocular and stereoscopic; convergence has been acquired, and the macula further developed. In this new use of the fixation reflex, the eyes are to an increasing degree, acting independently of the other receptive organs, except the sense of touch.

Further, the primate has begun to take an active interest in its surroundings apart from what concerns self-preservation and food. It has begun to "look-about"; the curiosity of the monkey is proverbial! Although there is a direct connection between these new uses of the eyes and the increased rate of blinking, yet the old primitive blink of the self-preservation reflex, in association with the other sense organs, still remains exactly as in the lower animals. The aural or acoustic reflex blink was seen by Blount[1] in the Sudanese monkey, as in the elephant, at the click of his stop-watch.

Two further points of interest were also observed by him in the arboreal primates: (i) The rate in the chimpanzee rose from eleven to twenty-four per minute on the approach of its keeper, and (ii) in the Sudanese monkey it rose from 45 to 75 per minute when the animal was, purposely, teased. As will be shown later, these latter results are closely similar to those obtained in man.

Blinking in man

The rate of blinking in man varies so widely in the same person under different surrounding circumstances that it is difficult to speak of an average rate, without giving the circumstances at the time. Thus, whilst Ponder and Kennedy[9] found an average rate of 16 per minute in 100 persons sitting in street-cars; that of 57 normals (recorded in Test 1) when talking with a stranger was 25·4, whilst when "reading aloud," under the same surroundings, had only been 3·29 per minute. On the whole it is greater in man than in the lower animals and closely similar to that in the arboreal primates. As in them, the eyes are used to guide the many further uses to which the hands have been applied by man in the development of the various arts and handicrafts from which civilisation has been evolved. For all this the independent use of the fixation-reflex in constantly changing directions has become increasingly essential, in order to meet the needs of the particular action in progress at the time. During this the extra-macular

reflex, for purposes of self-preservation, is necessarily out of full action, but it still remains in its primitive ancestral form and, at any moment, should danger threaten, is ready to shut off fixation by a blink, and to assume control in co-operation with the other sense organs. Thus, in Test 1, the aural or acoustic reflex blink occurred in no less than three of the normals when reading aloud. It followed a sudden ring of the telephone in one person and loud knocks at the door in two.

Further, the menace-reflex can be produced in man, as in the lower animals by suitable means. Rademaker and Garcin[10] produced it, in man, under the same conditions as in the cat, but failed to do so in the first few months of human infancy, " Ce réflex manque . . . ' dans les premiers temps que suivent la naissance '."

Until binocular vision and fixation have been acquired the rate of blinking in the human infant is not greater than that of an adult lower animal.

On the other hand there is ample evidence that at the level of the primates and still more in man, blinks closely allied to, but of less urgency than, the aural or menace reflexes, frequently arise from internal, emotional or nervous causes, that is, from imaginary, rather than real, threats. As was seen in Test 1, the average rate of blinking in the normals went up from 3·29 when reading to 25·4 when in conversation with a stranger; Ponder and Kennedy[9] found the rate go up from 12 to 20 per minute in a witness in Court when coming under cross-examination, and, further, state[9] that they found the rate trebled in a man whom, for experimental purpose only, they had made angry. This agrees with Blount's[1] findings in the Sudanese monkey when teased.

Blinking in the blind

In addition to the voluntary blinks of Group A, and those for the local protection of the eye itself, Group B, blinking occurs in the blind, even when congenital in origin, indistinguishable from that of Group C in normal persons. This was the conclusion come to by Ponder and Kennedy[9] in their examination of over 200 blind persons, and it is confirmed by the records given in Test 4.

Further, it is now known that the aural or acoustic-reflex blink occurs in the congenital-blind at a sound of alarm exactly as it does in other vertebrates, and in man with normal sight. This has been demonstrated, since the polygraph records were made in the boy, F.H. (aged 6 years), by Dr. A. B. Nutt, medical officer to the Sheffield Blind School. He obtained it by making a sudden loud bang on the door, whilst keeping the boy in conversation.

This original observation shows that, even in the congenital-blind person in whom the act of fixation has never taken place, the eye still retains its place in the nerve-centre alongside the other sense organs for purposes of self-preservation. When danger threatens, orders are transmitted to it to take its part just as if it were fully capable of so doing. The only part that it can carry out is to " clear the decks for action " by a blink, as its ancestors have done for countless ages.

The purposes of blinks in Group C

The immediate purpose of every blink in this Group is to cut short the fixation reflex,* without interrupting the continuity of vision. It is the automatic shutter by which the controlling nerve-centre puts the extra-macular reflex into full action.

This may be either (1) for the purpose of self-preservation, or (2) in order to change the direction of vision.

(1) For self-preservation the extra-macular reflex blink is needed : (*a*) When there is a warning of real and immediate danger to life, as in the aural and menace reflexes. These are seen throughout the animal kingdom, and are a part of a primitive, inherited, unconditioned reflex, in which all the receptors act together in close co-operation. The blink is the first of the many duties of the eyes when danger threatens; in the human congenital-blind it is the *only* one which they can carry out normally.

In the comparative security of civilised life, the blinks of this sub-group are less required than in animals living in the state of Nature. They are the more readily elicited the more deeply fixation is " set."

Much more common in man, but seen also in the lower primates, are blinks of similar type which may be classed as Sub-group (*b*) : Here the warning is not of immediate danger to life, but of something to be feared from the surrounding conditions, sufficient to warrant the receptor organs to be on the alert. These are the blinks seen in states of nervousness, emotion or excitement. Their frequency and their occasions vary widely with the individual's " make-up." They form a large proportion of the blinks in the every-day life of man. The fact that a sense of " loneliness amongst strangers " is often a factor suggests the ancestral fear

* That a closure of the lids does cut short the fixation-reflex, even when " spasmodically set," has been shown by Gordon Holmes ([5]) in a man with " spasm of fixation," who, once he had fixed his eyes on an object, could not take them off again. The shutter had ceased to function *automatically*, owing to disease. If, however, " fixation was broken by placing a screen in front of his face, *or by blinking* (italics ours), his eyes at once slid back."

of " separation from the herd." The increased blinking of persons in conversation with strangers (Test 1), or of the witness under cross-examination, or of the person made angry belong to this Sub-group. They are inherited reflexes conditioned by various unwritten laws and convenances, of which civilised society demands the observance.

As Nutt has shown that blinks of Group 1 (*a*) occur in the congenital-blind, it is reasonable to infer that they have blinks of sub-group (*b*) also, given the surrounding conditions which produce nervousness or emotion in persons with normal sight.

The blinks of this sub-group (*b*) are fewer in the chronic encephalitics (Test 1), in whom loss of the emotions, or loss of expressing them, is so striking a feature. Their reduced rate of blinking is also to be attributed to the muscular rigidity which prevents them from " looking-about " (Group 2).

Group (2). *To change the direction of fixation.*—Whilst the act of changing the direction of vision is one of the primitive functions of the extra-macular reflex, and of vital importance in the reflex of self-preservation, the increased, and more recently acquired, independent use of fixation for looking-about, and for guiding the movements of the hands calls for changes in direction of vision far more frequent than those required in the lower animals. As was shown in Test 3, they form a large proportion of the blinks seen in man, when asked to look from one point in space to another. Apparently, in most persons this is done by shutting off fixation, so that the change can be made by the extra-macular reflex, but this is not so in all, or at every change.

Possibly the distance apart of the two objects, or the uncertainty as to the exact position in space of the second play some part in this difference of procedure. Possibly, also, some few persons have acquired the habit of moving the eyes, so-to-speak, " on the fixation-reflex " for long distances, just as everyone does for short ones as when reading from word to word or from line to line. As was shown in Test 2, a few blinks when reading aloud, did come under this Group 2, as when " turning over the page."

These blinks do not occur when fixation begins on the new point, nor so long as it continues there, but only at the moment when it has to be ended in order that the extra-macular reflex may move it elsewhere.

It must not be inferred from the above that a blink is always necessary to bring the act of fixation to an end. On the contrary it is probable that it usually ceases especially in the lower animals by a mere relaxation of the muscles as does any other muscular action. Probably the only times when the automatic blink is called for in order to cut fixation short, is when the call for the

extra-macular reflex is more or less urgent, or when fixation is more deeply and independently "set" as it often is in the primates.

Purpose of blinks in Group D

These form the bulk of the blinks in the special act of reading aloud, and are indeed "blinks of technique," the purpose of which is to interrupt the visual incoming of the written word in order to delay its outflow in speech. Their duration varies with the marks of punctuation of the text, at which the blinks of this Group mostly occur. They differ from the blinks of Group C in that they *do interrupt vision,* for just so long as the accomplished reader thinks desirable. They are not followed by any change in the direction of fixation, which resumes at the same point at which it was before. Probably they were begun, in the first instance, as voluntary closures of Group A, but in the course of training, they have become, in the accomplished reader, conditioned reflexes. As was stated above (Test 2) some few of the blinks when reading aloud belong to Group C (2), and are for the purpose of changing the direction of fixation. That the "blinks of technique" are not of "nervous" or emotional origin is shown by the fact that, unlike those of Group C (1) they are not reduced in number in the chronic encephalitics (Test 1).

Conclusions

Apart, and distinct from, those reflex blinks seen in animals and man which are solely for the local protection and efficient action of the eyes themselves (Group B) every blink in man is the muscular act by which the controlling nervous centre automatically shuts off the act of fixation in order to put the extra-macular reflex into full action. (The purpose is slightly different in the blinks of Group D.)

The reasons for the blinks may be:—

1. *For self-preservation,* either from a threat of real danger to life coming from without through any of the sense-organs, or from undefined fears aroused by the surrounding conditions at the time. The former, Group C, I (*a*), is the primitive unconditioned reflex seen throughout the animal kingdom; the latter, Group C, I (*b*), is probably of the same origin but conditioned in the primates by the increased security of arboreal life and in man still more, by the requirements of civilisation. They form a large proportion of the blinks in everyday life.

2. *To change the direction of fixation.* (Group C, II).—Whilst some are but a part of the orientation of the head and eyes

in the self-preservation reflex, far more, especially in the primates, are either for " looking about " or to aid the various purposes for which fixation is used independently.

3. *To make pauses in the act of reading aloud.* (Group D.)—These are conditioned reflexes acquired by training.

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WORD BLINDNESS: ITS CAUSE AND CURE*

BY

RONALD HALL

OF H.M. FOREIGN SERVICE

DR. ORTON'S book " Reading, Writing and Speech Difficulties in Children " may be regarded as a standard work on word blindness. It seems, however, to do little more than describe this complaint without pointing to an effective remedy.

Dr. Orton records that Hinshelwood in 1917 produced a monograph on this subject in which it was asserted that word blindness was not due to defective vision. Hinshelwood, however, drew attention to two facts, namely (1) several cases of word blindness often occur in one family and (2) that symptoms displayed are very similar to those of adults who have lost the capacity to read because of brain injury, *i.e.*, damage to the angular gyrus of the dominant hemisphere. He therefore assumed a congenital defect of development of this area of the brain in word blind children.

Dr. Orton points out that there is no subsequent evidence to support this hypothesis as such areas of agenesis are rarer in the general autopsy service than is word blindness in children.

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